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PRESENTATION 4.1

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OPERATIONAL EFFICIENCY

SPACE TRANSPORTATION AVIONICS TECHNOLOGY SYMPOSIUM

OPERATIONAL EFFICIENCY

PANEL FINDINGS

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STATS - OPERATIONAL EFFICIENCY

Introduction

- **OPERATIONAL EFFICIENCY COVERS ALL TECHNOLOGY DISCIPLINES AND PROGRAMS**
  - There Is, However, More To Operating Efficiently Than Judicious Use Of Technology (e.g. Appropriate Organization Structure, Clean Interfaces Between Disciplines, Etc.)
  - Separate Efforts Are Underway To Address These Issues (e.g. JSC Mission Operations Efficiency Study, KSC Launch Operations Efficiency Study)
- **CROSS PANEL TECHNOLOGY NEEDS SHOULD BE INTEGRATED**
- **STATS PROVIDED BROAD MIX OF PROGRAM TECHNOLOGY NEEDS, TECHNICAL DISCIPLINE NEEDS, TECHNOLOGY AVAILABILITY**
  - Specific Technology Needs Must Be Defined And Prioritized Against TBD Meta- Program Requirements
  - Technology Needs vs Technology Availability Analysis Can Then Be Performed To Define Holes

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Ascent Flight Design *

- **KEY FINDINGS**

  - An Opportunity Exists For Progressively Automating And Standardizing The Ascent Flight Design Process Through The Use Of Advanced Technologies
  - Over Time, The Ascent Flight Design Process Will Evolve From Ground-based Technologies To Launch Vehicle-based Technologies
  - Launch Vehicle On-board Ascent Flight Design Capability Will Significantly Reduce Pre-launch Support Requirements And Improve Launch Probability
  - There Is Currently No Integrated Code M / Code R Plan For Exploiting This Opportunity

* COVERS BOTH <u>AUTOMATIC FLIGHT DESIGN</u> AND <u>ATMOSPHERIC ADAPTIVE GUIDANCE</u> TOPICS

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Ascent Flight Design *

- **TECHNOLOGY NEEDS**
  - Full Integration / Automation Of Distributed Ground Processes
  - On-board Computational Capabilities
  - On-board Upper Wind Measurement Systems (e.g. LIDAR)
  - Large Data Base Systems
  - Better Atmospheric Modeling
  - On-board Parallel Processing Hardware & Software
  - Advanced Sensors: Winds, Air Loads, Etc.

* COVERS BOTH AUTOMATIC FLIGHT DESIGN AND ATMOSPHERIC ADAPTIVE GUIDANCE TOPICS

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Ascent Flight Design *

- **CULTURAL CHANGES**
  - Use Standard Trajectory Designs Rather Than Optimum Designs (Flight Vehicle & Simulators)
  - Synergize Effort With DoD ELV Flight Design Systems
  - Stop Late Changes To Vehicle Constraints
  - Crew / Ground Controller Acceptance Of Standard I-loads

- **FACILITIES**
  - No New Facilities Required

* COVERS BOTH <u>AUTOMATIC FLIGHT DESIGN</u> AND <u>ATMOSPHERIC ADAPTIVE GUIDANCE</u> TOPICS

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Autonomous Spacecraft Control

- **KEY FINDINGS**
  - Needs Of This Program Seem To Duplicate DARPA "Pilots Associates Program" - Integration Needed
  - Very Broad Area - Covers Many Technologies And Programs
  - Will Become Increasingly Important As Requirements For Automated Rendezvous And Docking, Remote Descent / Ascent, And Autonomous Surface Operations Increase

- **TECHNOLOGY NEEDS**
  - On-board Task Planning & Management Systems
  - Intelligent GN&C Systems
  - Advanced Sensors
  - Intelligent Effectors
  - Standardized Spacecraft-to-Spacecraft Interfaces

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Autonomous Spacecraft Control

- **CULTURAL CHANGES**
  - Center & Organizational Responsibility Overlap Causes Duplication Of Efforts - Ineffective Use Of Resources
  - Will NASA Accept Autonomous Operation Of Manned Spacecraft Or With Unmanned Spacecraft Docking With Manned Spacecraft?
  - NASA Needs To Assure Cross Utilization Of Control System Hardware & Software Between Programs

- **FACILITIES**
  - Not Addressed

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Operations Management Systems

- **KEY FINDINGS**
  - OMS Is A Major Need Across All Programs And Becomes Mandatory With Program Complexity - e.g. SSF
  - Ground And On-board, Manned And Unmanned Applications
  - NASA Needs Cross-program Coordinated Effort For This Complex Discipline (M, S, R, E)

- **TECHNOLOGY NEEDS**
  - Artificial Intelligence
  - Advanced Computer & Software Architectures
  - Software Commonality (Retrofit Current Programs, Drive Future Programs)
  - Advanced Man-Machine Command & Control Interfaces

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Operations Management Systems

- **CULTURAL CHANGES**
  - This Must Not Be Assumed To Be An Easy Task
    - Distributed Development Of An OMS For A Complex Spacecraft Will Introduce Significant Program Risk
  - Crew Members Want To Know (And Have The Capability To Control) <u>Everything</u> About Their Vehicle

- **FACILITIES**
  - Integrated Test Bed At JSC

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Advanced Mission Control

- **KEY FINDINGS**
  - Earth-based Ground Support To Space-based Operations (Orbital Operations, Planetary Surface) <u>Must</u> Be Automated To A High Degree To Reduce Resources Needed For Continuous Long Term Programs (e.g. SSF, Lunar, Mars)
  - The "Capture" And Utilization Of Systems Data From Current And Past Programs Is A Vital Aspect Of This Technology
  - Technologies So Developed May Be "Transported" To Orbital And Remote Surface "Control Centers"

- **TECHNOLOGY NEEDS**
  - Large Scale Knowledge & Data Bases
  - Automated Knowledge Acquisition, Storage, Utilization
  - Qualitative / First Principles Reasoning
  - Autonomous Trend Analysis
  - Ability To Accept And / Or Express Processed Data In The "Language" Of The User

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Advanced Mission Control

- **CULTURAL CHANGES**
  - Joint Funding Of Research And Advanced Development As Technology Matures
  - The Need To Transition From Old (But Proven) Flight Control Technologies And Methods To New (And As Yet Unproven) Technologies And Methods Is Often Difficult To Sell

- **FACILITIES**
  - ARC AI Research Laboratory

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Telerobotics / Telepresence

- **KEY FINDINGS**
  - Development Work At JPL, ARC, And LaRC Not Adequately Covered; Program Needs Better Cross Center / Program Integration
  - Integration Of Inter-center A&R Research Is Vital
  - Telerobotic Research Has Not Adequately Been Bridged Into Mainstream Applications
  - A&R Will Be <u>Enabling</u> To Programs Such As SSF, ACRV, OMV, Lunar / Mars Exploration

- **TECHNOLOGY NEEDS**
  - Advanced Manipulators
  - Global / World Data Base
  - Fault Tolerant Systems
  - Sensors
  - Display Technologies
  - Collision Avoidance
  - Human Factors

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Telerobotics / Telepresence

- **CULTURAL CHANGES**
  - Telerobotics Technologies Not Well Accepted Throughout NASA (e.g. FTS)
  - Centralization Of Telerobotics / Telepresence R&D Effort Could Save Agency $$$ (Currently, Every NASA Center Has A&R Research Labs)

- **FACILITIES**
  - No New Facility Requirements Identified

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Advanced Software Integration

- **KEY FINDINGS**
  - Complex / Long Term Programs (e.g. SSF, Lunar, Mars) Will Require Major Advancements & Commitments To Advanced Software Integration Technologies And Capabilities
  - The More Distributed The Development Of Application Software Packages, The Greater The Need For A Centralized Software Integration, Testing, And Verification Capability Prior To "Flight"

- **TECHNOLOGY NEEDS**
  - Distributed Software Security
  - Modeling Of Complex Distirbuted Software Systems
  - Software Standards Development
  - Virtual Target Environments

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Advanced Software Integration

- **CULTURAL CHANGES**
  - Design / Operational Problems Involving Long Term Missions & Complex Software Integration Requirements Are Often Underestimated
  - Future Integration Of SSF And STS Software Development And Maintenance Concepts / Facilities Will Be Required For Economic (And Practical) Reasons

- **FACILITIES**
  - Integrated Test & Verification Facility At JSC (Multi-program Support)

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Advanced Test / Checkout Systems

- **KEY FINDINGS**
  - NASA Needs To Make An In-depth Analysis Of Aircraft Industry (Commercial & Military) Test & Checkout Methods
  - Launch Vehicle And Payload On-board Test Capability Should Greatly Reduce Ground Support Requirements

- **TECHNOLOGY NEEDS**
  - Better Life Cycle Cost Analysis Tools / Methods
  - Artificial Intelligence
  - Data Storage Devices
  - Distributed Computer / Software Systems

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Advanced Test / Checkout Systems

- **CULTURAL CHANGES**
  - Program Commitment To Launch Vehicle And Payload On-board Test And Checkout
  - Syndrome Requiring Test And Re-test Of Systems
  - Inabililty To Accept Autonomous Operations

- **FACILITIES**
  - Need A Test Facility Where High Fidelity Transportation Systems And Payload Systems On-board Autonomy Can Be Demonstrated

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Health Status and Monitoring

- **KEY FINDINGS**
  - Health Status Covers End-to-End Process: Component Manufacturing, Testing, Pre-flight, Flight, And Post-flight Elements
  - Health Status And Monitoring Capabilities Must Be Incorporated Early In DDT&E
  - Important To Define Key Parameters To Be Monitored Within Each Process Element, To Define Inter-element Parameter Dependencies, And To Integrate And Status Realtime Parametric Data

- **TECHNOLOGY NEEDS**
  - Design Knowledge Capture, Utilization And Maintenance
  - Embedded Sensors (Smart)
  - Large Data Bases (Integrated Data / Knowledge)
  - Distributed Computer & Software Architectures (Highly Reliable)
  - High Speed Data Analysis (Pattern Matching)
  - Techniques For Inferred Monitoring

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Health Status and Monitoring

- **CULTURAL CHANGES**
  - NASA Doesn't Consider HS&M To Be A High Priority - Requirements Deleted Under Budget Crunches
  - Incidents Such As The Recent DC-10 Fan Disk Failure Illustrate The Importance Of This Technology To Mission Success And Crew Safety

- **FACILITIES**
  - Not Addressed

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Advanced Training Systems

- KEY FINDINGS
  - As NASA Moves To More Autonomous Operations, Intelligent Computer-Aided Training (ICAT) Will Be Required To Assure Operational Efficiency Maintenance
  - Specific Applications Are Ready For Placement Into Current NSTS Program Operations

- TECHNOLOGY NEEDS
  - Knowledge Acquisition Tools
  - Advanced Computer Architectures
  - Advanced Simulation Techniques
  - Virtual Systems

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Advanced Training Systems

- **CULTURAL CHANGES**
  - Management Acceptance Of ICAT Technologies Is Good

- **FACILITIES**
  - Not Addressed

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Bottom Line

Operational Efficiency Is Not A Major Technical Problem.

It Is A Cultural (Political / Funding) Problem!